

Technical Validation

Optimizing Efficiency and Performance with Azure Stack HCI

Microsoft Azure Hybrid Cloud Offering, Powered by Intel Technology, Modernizes Infrastructure, Consolidates Virtualized Workloads, and Increases Efficiency

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ESG Technical Validations

The goal of ESG Technical Validations is to educate IT professionals about information technology solutions for companies of all types and sizes. ESG Technical Validations are not meant to replace the evaluation process that should be conducted before making purchasing decisions, but rather to provide insight into these emerging technologies. Our objectives are to explore some of the more valuable features and functions of IT solutions, show how they can be used to solve real customer problems, and identify any areas needing improvement. The ESG Validation Team's expert third-party perspective is based on our own hands-on testing as well as on interviews with customers who use these products in production environments.



Introduction

This ESG Technical Validation highlights the benefits of cloud-delivered, cloud-managed, on-premises Azure Stack HCI. We focus on the simplicity, flexibility, scalability, and performance capabilities of Azure Stack HCI. We also examine the delivery as a service and how integration with the Azure management plane provides an integrated and more efficient management experience.

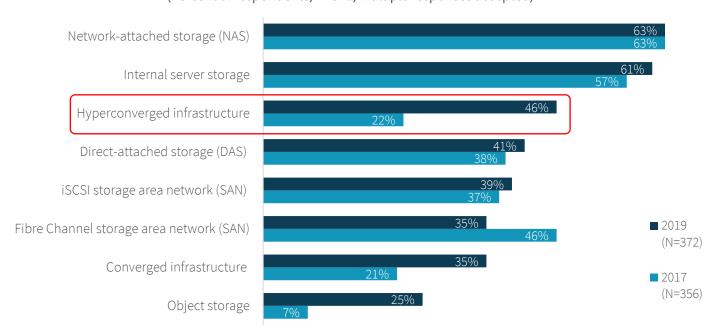
Background

As organizations modernize their IT infrastructure, many are shifting from a traditional three-tier architecture to a hyperconverged infrastructure (HCI). This architecture integrates compute, storage, networking, and virtualization into a single platform with a unified management plane. HCI platforms that deliver a cloud-like experience on-premises accelerate the transition to hybrid multi-cloud and enable simple and rapid mobility of cloud-native applications between the public cloud and an on-premises private cloud. These capabilities drive organizations to invest in HCI, and, according to ESG research, HCI has significantly been gaining momentum year over year (see Figure 1).¹

Figure 1. On-premises Storage Technologies in Use

In terms of what is deployed in your organization's data center(s), which of the following onpremises storage technologies are currently in use?

(Percent of respondents, N=372, multiple responses accepted)



Source: Enterprise Strategy Group

In ESG's annual technology spending intentions survey, 24% of organizations said that deploying hyperconverged infrastructure was one of the areas of data center modernization in which they would make the most significant investments in 2020, and 93% of organizations indicated that spending on hyperconverged technology would be sustained at current levels or increase in 2020.²

¹ Source: ESG Master Survey Results, <u>2019 Data Storage Trends</u>, November 2019.

² Source: ESG Master Survey Results, <u>2020 Technology Spending Intentions Survey</u>, January 2020.



As organizations make accommodations for workplace changes from the COVID pandemic, 21% of organizations will increase their original 2020 budgets to invest in private/hybrid cloud infrastructure software and 20% will increase their 2020 budgets for data center infrastructure.³ Organizations view hyperconverged and cloud infrastructures as an integral part of their modernization strategy, and HCI is now powering mission-critical production applications.

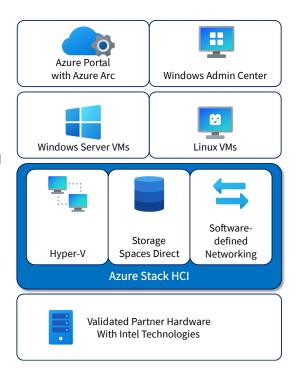
Azure Stack HCI

Azure Stack HCI is a hyperconverged infrastructure host operating system designed by Microsoft to pool on-premises and cloud resources, maximizing storage, performance, scalability, and functionality, now with built-in Azure hybrid capabilities. As part of their Azure subscription, customers will get regular feature and security updates for Azure Stack HCI. Organizations can use Azure Stack HCI to run Windows and Linux virtual machines and containerized applications on-premises or at the edge, leveraging existing tools, processes, and skill sets. Data centers can extend to the cloud with Azure Backup, Azure Monitor, and Azure Security Center, and Microsoft is continuing to add Azure services to this list.

Microsoft designed Azure Stack HCI to take advantage of cloud capabilities with simplified access to cloud management and Azure services. Azure Stack HCI enables organizations to modernize their infrastructure and consolidate virtualized workloads, reducing costs and increasing efficiency.

Four pillars informed the design and development of Azure Stack HCI:

- Azure hybrid by design—Centrally manage and monitor clusters from Azure Portal and benefit from fleet management for hosts and VMs using native integration with Azure Arc and Azure Monitor, and connections to Azure hybrid services like Azure Defender, Azure Backup, and Azure Site Recovery.
- Enterprise scale and great price performance—Modernize compute and storage infrastructure, consolidate virtualized and containerized workloads, and reduce costs while gaining cloud efficiencies onpremises.
- **Simplified operations**—Leverage familiar Windows Server, Hyper-V, PowerShell, and Azure skill sets to simplify and accelerate deployment, management, automation, and orchestration.
- Deployment flexibility—Deploy using appliance-like solutions
 validated and optimized for specific use cases or leverage the
 comprehensive portfolio of x86 servers and hardware components
 to customize a platform to meet specific performance, capacity,
 scalability, and cost requirements.



The Azure Stack HCI foundation incorporates the Hyper-V virtual machine hypervisor (the same hypervisor that powers the Azure public cloud), Storage Spaces Direct software-defined storage (SDS), and network virtualization (software-defined networking, SDN). Local deployment and management use the familiar Windows Admin Center, System Center, and/or PowerShell, and Azure integration provides a cloud management plane. Azure Stack HCI integrates Azure services into

³ Source: ESG Master Survey Results, <u>Technology Impact of COVID-19: IT Decision Maker (ITDM) View</u>, May 2020.



Windows Admin Center for offsite backups, site recovery, and cloud-based monitoring, with other services always being added. Administrators can script automation and orchestration using PowerShell.

Key software-defined storage features include fault tolerance similar to RAID and implemented via software, stretch clustering with storage replication for business continuity/disaster recovery (BC/DR), and a cloud witness for quorum; security via data encryption at rest and in flight; and efficacy via a kernel-embedded architecture, RDMA, data deduplication, data compression, and per-VM quality of service (QoS) input/output per second (IOPS) limits. Azure Stack HCl can scale out and scale up from two to 16 servers and eight to 400 storage devices, including Intel Optane NVMe SSDs, NAND NVMe, SATA, and SAS, up to a maximum of 4 PB. Intel Optane persistent memory, NVDIMM for In-memory, persistent memory, caching, and real-time tiering enhance performance and VM density.

Azure Stack HCI includes software-defined networking and network virtualization features including host and guest RDMA, tenant isolation, distributed routers, virtual network peering, and QoS. SDN provides fault tolerance via a high-availability control plane, M:N redundancy, and active-active L3/L4 software load balancing. Security comes from hypervisor enforced firewalls, logging, port mirroring, and third-party virtual security appliances. Azure Stack HCI can live migrate VMs across physical networks to minimize downtime.

Azure Stack HCI is a cloud-delivered, on-premises HCI solution. Integration with Azure extends to licensing and fees, and the solution is provided on a subscription basis, with charges appearing as a line item on the monthly Azure bill. This enables fast deployment and, in principle, instant scale up or scale down as workloads and requirements change, forgoing the time consuming and difficult budgeting and capital expense approval processes. Note that the licenses for the guest virtual machines are not included as part of the Azure Stack HCI subscription.

Azure Stack HCI is suited for multiple use cases including:

- Branch office and edge—Organizations benefit from resilient storage and high-availability application infrastructure that can support traditional business-critical applications and new container and IoT edge workloads using small footprint, low-power, low-cost, two-node switchless configurations.
- **Virtual desktop infrastructure (VDI)**—Organizations can deploy VDI at scale via a virtual desktop broker such as Microsoft Remote Desktop Services and, in the medium term, Citrix Virtual Apps and Desktops.
- Online transaction processing (OLTP)—Microsoft SQL Server VMs and other enterprise database platforms can leverage the performance, scalability, availability, and manageability of Azure Stack HCI for mission-critical OLTP applications.
- Business continuity and disaster recovery (BC/DR)— Azure Site Recovery and Storage Replica enhance BC/DR, and native stretch clustering provides automatic failover to restore production quickly and without the need for manual intervention.
- Enterprise virtualization—Azure Stack HCI provides performance, availability, and security for a mix of application workloads hosted in VMs. Virtualization-based security (VBS) uses the Hyper-V hypervisor to create and isolate a secure region of memory, segregating security-sensitive operations from the host operating system.
- Tightly integrated Kubernetes container workloads—Azure Kubernetes Service on Azure Stack HCI (AKS-HCI) automates and orchestrates containerized applications on Azure Stack HCI clusters. AKS-HCI simplifies Kubernetes deployment and management and ensures mobility of containerized applications between the cloud and on-premises clusters.



Azure Stack HCI provides a secure platform for these and other use cases and workloads. Monthly security and quality updates are available on the same "Patch Tuesday" timeline as Windows proper. Administrators can deploy updates without disrupting VMs or incurring cluster downtime using built-in Cluster-Aware Updating.

Intel Xeon Scalable processors, with performance optimized for HCI workloads and built-in AI acceleration, provide the compute foundation of Azure Stack HCI. Intel's hardware-enhanced security helps to thwart malicious exploits while maintaining workload integrity and performance. Efficient encryption provides trusted data service delivery at rest, in use, and in-flight. The Secured-core server collaboration between Microsoft, Intel, and OEMs simplifies enablement of advanced security features from the silicon up based on a hardware root-of-trust, extending up through the firmware, isolating parts of the system, and better protecting sensitive data like credentials. Hardware-enhanced virtualization and support for Intel Optane persistent memory (PMEM) accelerates the performance of Azure Stack HCI workloads.

Intel Optane Persistent Memory is a new memory technology that provides lower latency, large capacity, and support for data persistence. PMEM is packaged in DIMMs like traditional DRAM and resides on the same bus/channels as DRAM memory. Unlike DRAM, PMEM can operate in a persistent mode, storing data even without power applied to the module, which comes with added security to keep the data safe. And PMEM is available in 128 GB, 256 GB, and 512 GB DIMMs—much larger than DRAM DIMMs. Using Intel Optane PMEM enables organizations to increase memory capacity, lowering overall TCO while maximizing VM densities and simultaneously increasing memory security with automatic hardware-level encryption and protection from power failures.

Azure Stack HCI can leverage Intel Optane SSDs, which replace traditional NAND flash technology with Intel Optane technology, which is designed to deliver faster performance for low queue-depth workloads, exhibiting high throughput for single accesses and very low latency. Whereas flash must erase a 2KB-16KB block before writing, each Intel Optane technology location can be individually addressed and written. This results in an SSD providing consistent performance and latency regardless of write activity. Intel Optane DC SSDs can offer a high-performance data caching tier with ultra-high endurance, up to 100 drive writes per day (DWPD) to augment large SATA/NVMe storage capacity tiers with low endurance, under 3 DWPD. Using a two-tier methodology, the customer can have large low-cost flash-based storage models that are protected by the Intel Optane SSD endurance to sustain wear leveling on the overall storage array.

Azure Stack HCI uses non-volatile memory express (NVMe) for fast and efficient movement of data to traditional NAND and Intel Optane SSDs. NVMe supports massive parallelization, enabling vast amounts of parallel I/O operations over each node's PCIe bus, reducing bottlenecks and keeping data flowing to all the applications running in the cluster. Intel 3D NAND SSDs, including the P4610 and P4510 SSDs, extend capacity while providing consistent performance using the NVMe interface.

Intel Ethernet 800 Series network adapters enable Azure Stack HCI to move volumes of data efficiently and securely across on-premises, edge, and cloud infrastructures, supporting multiple storage protocols and maximizing virtual resources. Intel Ethernet 800 Series network adapters support 1G-200G Ethernet Speeds and both iWARP and RoCEv2 RDMA, enabling Azure Stack HCI administrators to choose from storage speeds and choice of RDMA.



ESG Technical Validation

ESG performed evaluation and testing of Azure Stack HCI using the Intel Solutions Engineering Lab. Testing and demonstrations were designed to demonstrate the simplicity and flexibility of on-premises and cloud management. We also examined the performance and scalability of the infrastructure for Online Transaction Processing (OLTP) and other use cases.

Simplicity and Flexibility of Local Operations

Windows Admin Center, designed to integrate with Azure Stack HCI, is local and always available. Administrators use Windows Admin Center for initial setup, hardware management, troubleshooting, and infrastructure management. Azure Stack HCI is tightly integrated with Azure, and customers can use Azure Portal, a cloud-based highly scalable management console providing global visibility, monitoring and security services, billing, and access to support.

ESG Testing

ESG explored typical local operations and management activities, focusing on the simplicity and flexibility provided by Azure Stack HCl's familiar Windows Admin Center console. We started with the dashboard for a previously configured and running deployment in a demo environment.

As shown in Figure 2, the dashboard summarizes key HCI state and performance indicators and provides at-a-glance understanding of the health and performance of the system. Cluster data included server and drive count and health, and CPU, memory, and storage usage. The dashboard also provided data on the number and health of virtual machines and storage volumes. Dashboard elements are updated in real time and administrators can drill down for more detailed information.

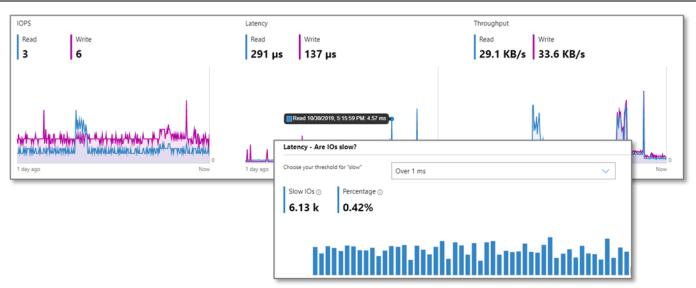
Storage usage (1) Virtual machines (Total 10) Volumes (Total 12) Running Warning Available Used Total size 10 1 3.67 TB 7.38 TB 11.1 TB CPU usage (I) (I) Memory usage Total Total 11% 29% 11% Servers (Total 3) Drives (Total 48) All servers healthy All drives healthy

Figure 2. Windows Admin Center: Azure Stack HCI Dashboard

Source: Enterprise Strategy Group

Next, we explored the Azure Stack HCI storage performance metrics. As shown in Figure 3, Azure Stack HCI records storage IOPS, latency, and throughput, and Windows Admin Center graphs these critical measures of performance. The dashboard also enabled rapid identification of storage performance issues by automatically displaying a graph of slow I/O transactions, with a user-selectable threshold for what constitutes slow. These visualizations enabled us to rapidly understand the current and optimal performance of the system.

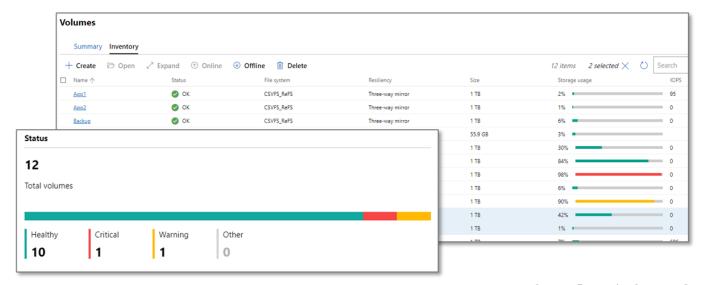
Figure 3. Windows Admin Center: Azure Stack HCI Storage Performance



Source: Enterprise Strategy Group

ESG next explored the storage volumes. As shown in Figure 4, Windows Admin Center displayed a volume summary showing the state of all volumes, and the volume inventory provided a list of volumes, detailing the file system type, resiliency, and size. Usage was displayed graphically, with colors indicating when usage was approaching the maximum. Windows Admin Center enabled us to rapidly and easily create, expand, delete, and manage volumes, and provided an ata-glance summary of volume status.

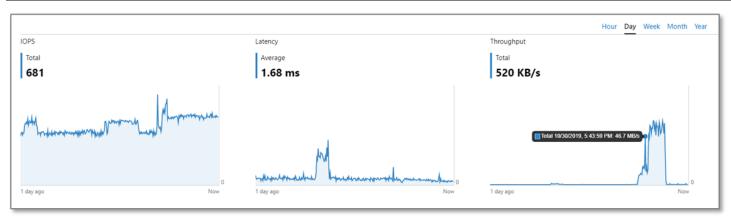
Figure 4. Windows Admin Center: Azure Stack HCI Volume Management



Source: Enterprise Strategy Group

We selected the *App1* volume and displayed the volume performance stats, as shown in Figure 5. As with storage performance, Azure Stack HCI tracks the performance of each volume. IOPS, latency, and throughput were displayed graphically, enabling us to rapidly identify any performance issues and ensure the system was operating correctly.

Figure 5. Windows Admin Center: Azure Stack HCI Volume Performance



Source: Enterprise Strategy Group

Next, we explored the virtual machines running on the Azure Stack HCI system. The familiar interface from Windows Admin Center displayed a list of all VMs with details, including the host server, CPU and memory utilization, and storage footprint, enabling us to rapidly understand the state of all VMs in the environment (see Figure 6). We could quickly and easily create, destroy, and manage VMs using the familiar Windows Admin Center UI.

Figure 6. Windows Admin Center: Azure Stack HCI Virtual Machine Management

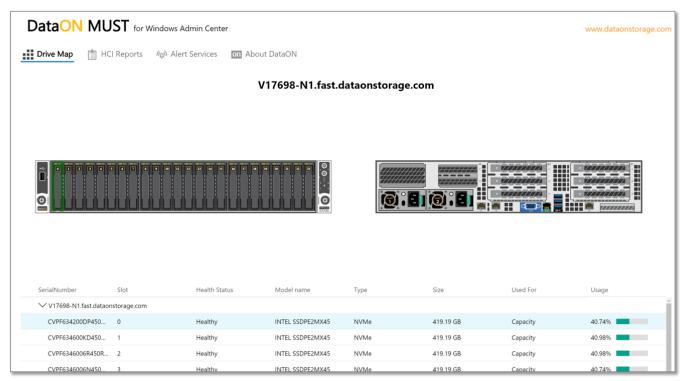
Summary Inventory								
+ New > Connect @	Settings D St	art Shut	down 🗄 Save	→ Move © Ne	w checkpoint	More ∨		36 items
Name ↑	State	Host server	CPU usage	Memory pressure	Memory dem		Uptime	Heartbe
Accounting-01	Running	Node1	1%	89 %	3.56 GB	Delete	0:13:23:00	OK
Accounting-02	Running	Node1	3 % 1	84 %	3.36 GB		0:13:11:34	OK
Accounting-03	Running	Node2	0 %	48 %	819 MB		0:13:22:46	OK
Accounting-04	Running	Node1	0 %	20 %	819 MB	₹ Export	0:13:22:49	ОК
Core-2019	Running	Node1	0 %	13 %	798 MB	Clone	0:13:22:37	OK
Corp-File-Server-01	Running	Node2	0 %	23 %	942 MB		0:13:22:58	OK
Corp-File-Server-02	Running	Node1	3 %	48 %	819 MB	Delete saved state	0:13:22:55	ОК
Corp-108-01	Running	Node2	1%	91%	819 M8	(Turn off	0:13:22:40	OK
Corp-108-02	Running	Node2	0 %	20 %	819 MB	Pause	0:13:22:34	OK
Corp-LOB-03	Running	Node1	1%	23 %	942 MB	D Resume	0:13:22:51	ОК
Corp-108-04	Running	Node1	0 %	48 %	819 MB		0:13:22:48	OK
HR-01	Running	Node2	3 %	75 %	3 G8	○ Reset	0:13:22:46	ОК
HR-02	Running	Node1	1%	21%	860 MB		0:13:22:31	ОК
HR-Legacy-01	Running	Node1	0 %	25 %	512 M8	Protect VM	0:13:22:54	ОК
LOB1-2019	Running	Node2	1 %	22 %	901 MB		0:13:22:28	OK
Marcom-01	Running	Node2	0 %	20 %	819 MB	Edit lags	0:13:22:25	ОК

Source: Enterprise Strategy Group

Microsoft hardware partners can create Windows Admin Center plug-ins to customize the management of hardware. We reviewed a plug-in that presented a graphical overview of the physical server showing the front and back panel, location of drives, and the status of I/O interfaces and power supplies. From the plug-in, we could review hardware configuration and status, simplifying hardware management and operation of the HCI system.



Figure 7. Windows Admin Center: Azure Stack HCI Hardware Management via Vendor Plug-in⁴



Source: Enterprise Strategy Group

(1)

Why This Matters

IT organizations quickly discover that delivering the simplicity, speed, accessibility, scalability, flexibility, self-service, and other benefits of private clouds can be a complex and painful exercise, requiring the coordination and integration of many components.

ESG validated that Azure Stack HCI combined compute, memory, storage, and networking resources into a comprehensive, integrated solution, eliminating the complex and arduous effort of connecting, integrating, and managing stacks of disparate equipment. We found that the familiar Windows Admin Center interface further simplified managing the cluster. Using Windows Admin Center enabled us to rapidly understand the current state and health of the cluster. We could easily manage storage, volumes, and virtual machines. Azure Stack HCI provided resource management flexibility, enabling us to balance competing needs for scarce resources.

⁴ This image is for example purpose only. It does not represent the system used for testing in this report.



Simplicity and Flexibility of Cloud Operations

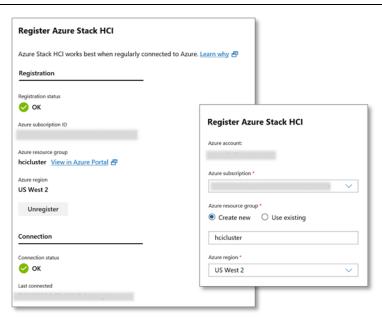
A key feature of Azure Stack HCI is the tight integration with Azure Arc, which simplifies management and operation of complex and distributed environments across on-premises, edge, and multi-cloud. The benefits of using Azure Arc to manage Azure Stack HCI and other cloud services include:

- Organize and govern across environments—Organize and manage resources such as Windows and Linux servers; Kubernetes clusters; and Azure data services with the Azure portal, Azure Lighthouse, scripting tools, and APIs. Enforce organization policies and standards and assess compliance at scale for all resources.
- Manage Kubernetes apps at scale—Deploy and manage Kubernetes apps with GitHub and Azure policy, ensuring that applications are consistently deployed and configured from source control.
- Run Azure Arc data services anywhere—Ensure consistency in data governance and security, manage costs efficiently, and use the latest innovations in cloud, automation, elastic scale, and unified management for data workloads running across hybrid infrastructure.
- Bring Azure security anywhere—Strengthen security posture and protect against threats with Azure Defender. Central management and role-based access controls simplify management and security for access to data and sources. Detect, investigate, and mitigate security incidents using Azure Sentinel, a cloud-native security information and event manager (SIEM).

ESG Testing

ESG explored managing Azure Stack HCI using the Azure Portal. We started by registering the Azure Stack HCI system with Azure, as shown in Figure 8. Registration was a quick and simple process, and, after entering our credentials, it was completed almost instantly.

Figure 8. Registering Azure Stack HCI with Azure



Source: Enterprise Strategy Group

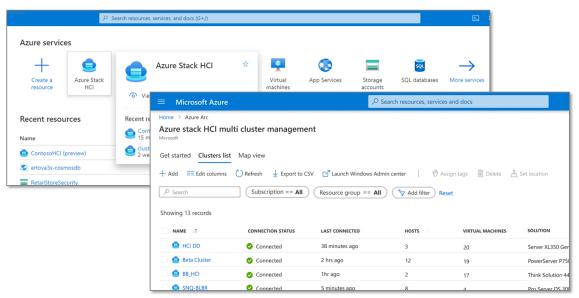
Despite being deployed on-premises, Azure Stack HCI is a "first-class citizen" in the Azure service. All Azure Stack HCI instances are visible in the Azure portal without having to resort to agents or custom scripts. Thus, administrators can take



advantage of the standard Azure Resource Manager constructs, including identity and access management and managing resources at scale.

As shown in Figure 9, Azure Stack HCI appears as one of many available resources in the Azure portal. Using the portal, we displayed the list of all Azure Stack HCI clusters, including status, connection, host, VM, and hardware solution details. As with all other Azure resources, we could tag and filter the Azure Stack HCI resources and select any resource to drill down for additional information and management options.

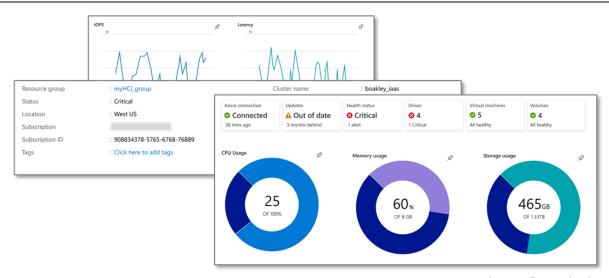
Figure 9. Native Integration of Azure Stack HCI into Azure Portal



Source: Enterprise Strategy Group

We selected the cluster, which displayed the Azure Stack HCI dashboard. As with the Windows Admin Center version of the dashboard, the Azure Portal version provided an at-a-glance summary of the state and health of the cluster, along with graphics showing the storage IOPS and latency performance. This dashboard integration enabled us to use the cloud portal to ensure all clusters in our environment were healthy and providing optimum performance for our workloads.

Figure 10. Azure Portal: Azure Stack HCI Dashboard

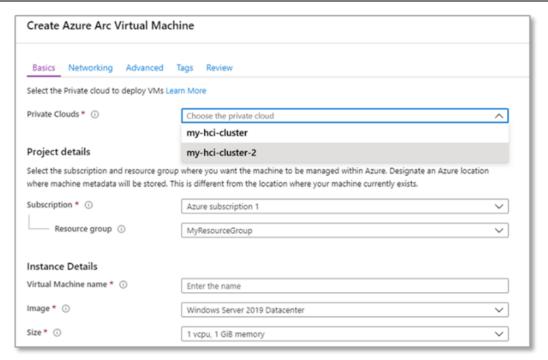


Source: Enterprise Strategy Group



Next, we previewed a feature which will be made available as part of the Azure Stack HCI service in the near future. We used the Azure Portal to create a virtual machine on an Azure Stack HCI cluster. The VM creation wizard walked us through the necessary steps and deployed the virtual machine on the cluster. We also observed that these actions were supported by APIs and we could write scripts to automate and orchestrate VM management from the cloud.

Figure 11. Azure Portal: Create an Azure Stack HCI Virtual Machine



Source: Enterprise Strategy Group



Why This Matters

The desired state of optimal performance, utilization, and compliance across a hybrid multi-cloud environment cannot be achieved using a series of on-premises point tools. Looking at any subset of infrastructure resources in isolation cannot achieve modern IT goals; the scale is simply too vast for humans with spreadsheets and a large collection of disparate management systems.

ESG validated that the tight integration of Azure Stack HCI into Azure enabled us to manage our on-premises Azure Stack HCI clusters as part of our Azure cloud resources. Using the Azure portal enabled us to evaluate and achieve optimal performance, utilization, and compliance. As Azure Stack HCI appears as another native Azure resource, we could leverage Azure APIs and scripting to automate and orchestrate Azure Stack HCI operations, and to integrate Azure Stack HCI into our Azure operating environment. The visibility, flexibility, insights, automation, and orchestration provided by the Azure integration ensures organizations can cost-optimize and deliver their required storage and compute capacity and performance on-premises and in the cloud.



Performance and Scalability

ESG validated the performance and scalability of Azure Stack HCI using two Intel Select Solutions configurations of four-node Azure Stack HCI clusters. The Intel Select Solutions base configuration used 2.0 GHz Intel Xeon Gold 6330 CPUs, providing 28 cores and 56 threads and 3200 MHz DDR4 DRAM. The Intel Select Solutions plus configuration used 2.6GHz Intel Xeon Gold 6348 CPUs, providing 28 cores and 56 threads, 3200 MHz DDR4 DRAM, and Intel PMEM 200 series Optane persistent memory. Both configurations included Intel Ethernet 800 Series network adapters running at 100 Gbps with RDMA to maximize data throughput. Both systems used a flat tier of NVMe data storage, which simplifies storage management and in-field support for any drive failures that may occur.

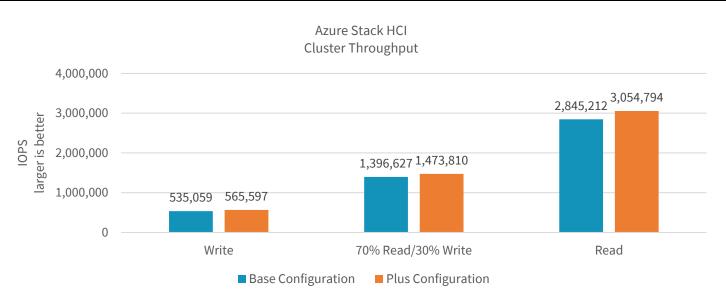
The validation began with a series of performance benchmarks to quantify the underlying storage performance and the benefits of Intel NAND SSD storage. The base configuration used four Intel P4610 SSDs, and the plus configuration used eight Intel P5510 SSDs. While the base configuration used four SSDs per node, the plus configuration used eight SSDs per node to provide comparable levels of endurance, recommended when used in a flat tier such as this configuration. Next, we validated the performance of the cluster running an analytics (OLTP/SQL) workload. Cluster configuration details are provided in Table 1 in the Appendix.

ESG Testing

ESG used VMFleet with DiskSpd, a storage load generator and performance test tool, to quantify Azure Stack HCI storage performance. VMFleet orchestrated the virtual machine deployment and workload deployment, and DiskSpd was used to generate different I/O patterns to the cluster to simulate typical I/O behavior of real-world systems. Due to the I/O blender effect of virtualization, I/O from all VMs is mixed and almost all HCI storage accesses are randomized, so we quantified the performance of randomized access. Of particular interest were 100% writes, simulating capturing streaming data; 100% reads, simulating bulk data transfer from storage to compute for analysis; and a mix of 70% reads/30% writes, simulating typical file I/O and OLTP transactions. DiskSpd benchmark parameters are provided in Table 2 in the Appendix.

Figure 12 shows the number of IOPS sustained by each configuration of the four-node Azure Stack HCI clusters for random I/O operations. Throughput was measured with a DiskSpd queue depth of eight.

Figure 12. Azure Stack HCI Storage Throughput



Source: Enterprise Strategy Group

⁵ DiskSpd is a storage load generator/performance test tool from the Windows/Windows Server and Cloud Server Infrastructure Engineering teams.

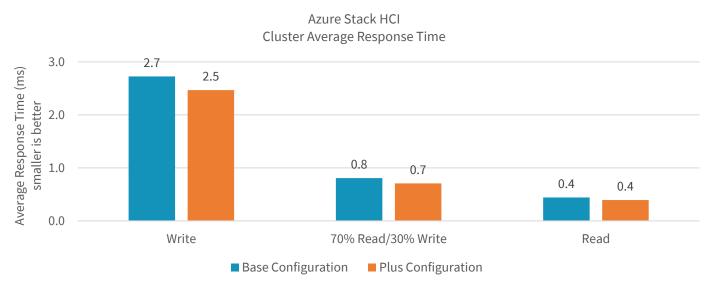


Azure Stack HCI Storage Throughput: What the Numbers Mean

- The base configuration of Azure Stack HCI sustained more than 2.84 million IOPS and the plus configuration sustained more than 3.06 million IOPS and more than 2 GB/sec data transfer with a 1.90 ms response time, demonstrating the ability of the solution to support the most demanding business needs for streaming and file access, OLTP, and other use cases.
- The plus configuration provided 5.7% more write throughput and 7.4% more read throughput than the base configuration.

Figure 13 shows the response time achieved by each configuration of the four-node Azure Stack HCI clusters for these I/O operations. Response time was measured with a queue depth of one, using DiskSpd.

Figure 13. Azure Stack HCI Storage Response Time



Source: Enterprise Strategy Group

Azure Stack HCI Storage Response Time: What the Numbers Mean

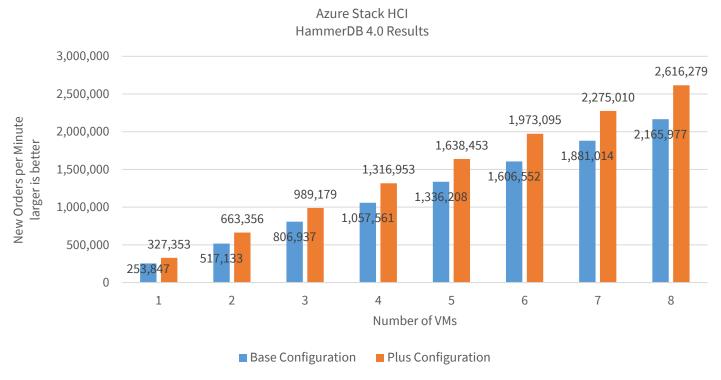
- Azure Stack HCI achieved sub-microsecond read response times and less than three microsecond write response
 times and can provide the speed, consistency, and predictability of storage operations necessary to support business
 critical workloads.
- The plus configuration demonstrated a 9.5% write response time advantage and a 10.9% read response time advantage.

Next, ESG quantified the performance of the Azure Stack HCl cluster for OLTP applications using <u>HammerDB</u>, an industry-standard open-source database load testing and benchmarking tool running on Microsoft SQL Server. The OLTP workload tested with HammerDB emulates the activity of users in a typical online brokerage firm as they generate trades, perform account inquiries, and execute market research. HammerDB benchmark parameters are provided in Table 3 in the Appendix.

HammerDB measures the number of new orders per minute that the system can generate (see Figure 14).



Figure 14. Azure Stack HCI OLTP Performance



Source: Enterprise Strategy Group

Azure Stack HCI OLTP Performance: What the Numbers Mean

- A single VM running Microsoft SQL Server Standard Edition on the base configuration of Azure Stack HCI was able to sustain more than 253,000 new orders per minute (NOPM), demonstrating that Azure Stack HCI running on Intel Xeon Scalable processors can support a heavy OLTP workload and simultaneously have compute, storage, and memory resources available to support other workloads running in the cluster.
- A single VM running Microsoft SQL Server Standard Edition on the plus configuration of Azure Stack HCI was able to sustain more than 327,000 NOPM, 29% more than the base configuration.
- Azure Stack HCI demonstrated linear scaling as the load was increased by adding additional VMs and additional
 HammerDB workloads. With eight VMs, the base configuration sustained more the 2.16 million NOPMs and the plus
 configuration sustained more than 2.61 million NOPMs, 21% more than the base. This demonstrates that Azure Stack
 HCI provides consistent and predictable performance as workloads put increasing demands on the system.





Why This Matters

Enterprise applications like SQL Server drive businesses every day and demand high performance for workloads such as OLTP and real-time analytics. To collect the massive data volumes needed and deliver virtually instant data access for applications such as online trading, fraud detection, retail customer interactions, and the like, these applications must be supported by an enterprise-class storage foundation. Large-scale consolidation of mixed workloads can increase cost efficiency as long as mission-critical workloads are assured of the highest performance and scalability to meet the demands of growing businesses.

ESG validated that Azure Stack HCI sustained 663,356 NOPM on a two-node two VM plus configuration cluster. Further, Azure Stack HCI showed near linear performance scaling as workloads increased. A four-node eight VM cluster sustained more than 2.6 million NOPM. In this configuration, 48 vCPUs per node were dedicated to the HammerDB benchmark. With Intel Xeon Gold 6348 CPUs providing 28 cores and 56 threads, the cluster still had 8 threads per node available for other workloads.

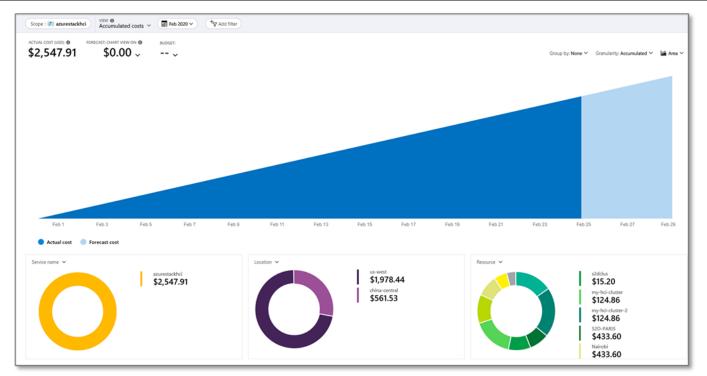
Azure Stack HCI provides reliable, predictable performance as we scaled workloads with minimal variability in performance throughout the test, which is meaningful in the real world. This can translate into support for a significantly higher density and performance of supported databases and applications.



Price/Performance

Microsoft offers Azure Stack HCI on a monthly subscription basis with a minimum one-month buy-in. The fee of \$10 per physical processor core per month is part of the Azure unified billing and appears as a line item in the organization's billing portal (see Figure 15). This pricing model enables organizations to license guests and apps separately. Costs are constant and predictable and don't vary with consumption or the number of virtual machines.

Figure 15. Azure Stack HCI Costs in the Azure Portal



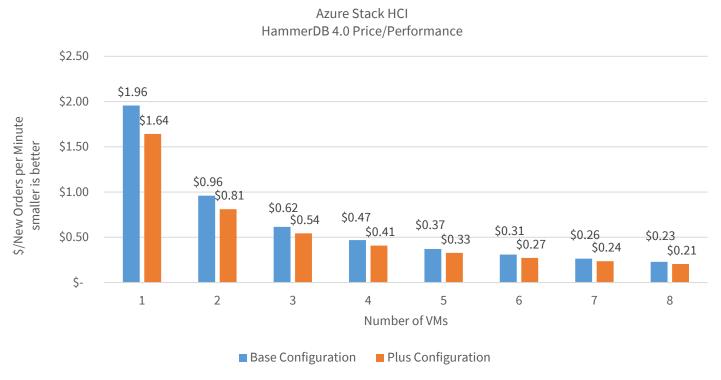
Source: Enterprise Strategy Group

ESG computed the cost of the test bench used for performance quantification using street prices estimated at the time of publication of this report. Total cost of the solution was calculated for a typical three-year deployment. The costs are provided in Table 1 in the Appendix.

ESG computed Azure Stack HCI OLTP price/performance when running HammerDB on a four-node cluster. Price/performance is shown in Figure 16.



Figure 16. Azure Stack HCI OLTP Price/Performance



Source: Enterprise Strategy Group

Azure Stack HCI HammerDB Price/Performance: What the Numbers Mean

- One VM running Microsoft SQL Server Standard Edition on a four-node base configuration Azure Stack HCI cluster was able to sustain more than 253,000 NOPM at a cost of \$1.96 per NOPM.
- As the number of VMs and workload increased, the price performance dropped, reaching \$0.23 per NOPM for more than 2.16 million NOPMs on a 4 node, 8 VM base configuration cluster.
- One VM running Microsoft SQL Server Standard Edition on a four-node Plus configuration Azure Stack HCI cluster was able to sustain more than 327,000 NOPM at a cost of \$1.64 per NOPM, a 16% price/performance advantage over the base configuration.
- As the number of VMs and workload increased, the price performance dropped, reaching \$0.21 per NOPM for more than 2.61 million NOPMs on a 4 node, 8 VM plus configuration cluster, a 10% price/performance advantage over the base configuration.
- The benchmark demonstrated that both configurations of Azure Stack HCI provide increasing cost efficiency as workloads and cluster size are increased to meet increasing business demands.
- By investing an additional 8% to upgrade from the base to the plus configuration, organizations can benefit from a 21% increase in maximum performance.





Why This Matters

Organizations could get the fastest performance by running their applications in memory, but the cost of that would be prohibitive. Therefore, IT is continually trying to balance performance with cost and efficiency, striving to service more users and add more business value with less infrastructure and cost.

ESG validated that by using Intel technology, Azure Stack HCI provides increasing cost efficiency as workloads and cluster sizes increase. This translates directly to improved agility and scalability as well as lower upfront and ongoing costs because a given workload can potentially be serviced by a smaller number of nodes. Azure Stack HCI can cost-effectively serve hundreds of thousands of customers and millions of operations per minute.



The Bigger Truth

Delivering high levels of performance is a requirement for IT environments that rely heavily on mission- and business-critical databases and applications. This is especially important in dynamic environments where data growth is constant and continuous accessibility is a requirement, often compounded by demand for new analyses and insights from the data. The ability to easily meet these performance and scalability requirements is essential for anyone deploying hyperconverged infrastructures.

The challenge is that as organizations embrace the public cloud and implement hybrid multi-cloud infrastructures, there is too much overhead managing on-premises and cloud services and operating at scale consumes scarce IT expertise.

Azure Stack HCI, the new hyperconverged operating system from Microsoft, integrates the Hyper-V hypervisor, software-defined storage, software-defined networking, and Azure, enabling organizations to consolidate physical and virtual workloads onto a cloud-delivered cloud-managed on-premises hyperconverged infrastructure cluster.

ESG validated the simplicity and flexibility of Azure Stack HCI, which combined compute, memory, storage, and networking resources into an integrated platform able to simultaneously support Microsoft Windows Server, Linux, and Kubernetes containerized workloads. The familiar Windows Admin Center local management solution enabled us to easily manage and balance competing needs for scarce storage and compute resources.

Azure Stack HCl's tight integration into Azure enabled us to manage our on-premises HCl clusters as part of our Azure cloud resources. The visibility, flexibility, insights, automation, and orchestration provided by the Azure integration enabled us to rapidly evaluate and achieve optimal cost, performance, utilization, and compliance across on-premises and public cloud resources.

Performance testing of Azure Stack HCI revealed:

- Using Intel SSDs enabled Azure Stack HCI to deliver effectively equal performance for random and sequential access. This is important in HCI solutions where, due to the I/O blender effect, nearly all I/O accesses are randomized.
- Using Intel Ethernet 800 Series network adapters, Azure Stack HCI sustained more than 3.06 million IOPS and more than 2 GB/sec data transfer with a 0.4 ms response time, demonstrating the ability of the solution to support the most demanding business needs for streaming and file access, OLTP, and other use cases. With RDMA, this performance was sustained even as the cluster size increased.
- Azure Stack HCI demonstrated linear scaling and was able to deliver more than 2.6 million NOPM in an OLTP workload benchmark. Azure Stack HCI running on 3rd Generation Intel Xeon Scalable processors provides consistent and predictable performance as workloads put increasing demands on the system.
- The cost per operation decreased linearly as workloads and cluster size increased, achieving a low cost of \$0.21 per NOPM at 2.6 million NOPM. This shows that Azure Stack HCI provides increasing cost efficiency as workloads and cluster size are scaled to meet increasing business demands.

Organizations in need of hyperconverged infrastructure that can scale from a two-node edge cluster to a 4PB cluster supporting mission-critical workloads should thoroughly evaluate the efficacy, functionality, and operational capabilities before purchasing or deploying any infrastructure solution.

Azure Stack HCI demonstrated impressive simplicity, flexibility, scalability, and performance. Integration with Azure for cloud-delivered, cloud-managed infrastructure consolidation enables organizations to modernize and future-proof their investment by adopting a true hybrid cloud infrastructure. ESG believes that organizations looking to optimize



manageability, performance, and costs while integrating edge and data center on-premises infrastructures into their hybrid multi-cloud environment to support mission-critical workloads should take a close look at Azure Stack HCI.



Appendix

Table 1. Validation Test Bed

Software			
HCI Cluster Software	Azure Stack HCI 2020H2 10.0.17784		
Virtual Machine Operating System	Windows Server 2019 Data Center: Azure Edition		
Database	Microsoft SQL Server Standard		
Estimated Software Cost	\$436,560		
Base Configuration			
CPU	Intel Xeon Gold 6330 28 Cores/56 Threads 2.0GHz		
Memory	256 GB 3200MHz DDR4 DRAM		
Storage	3.2TB Intel SSD DC P4610 Series 4 drives, 12.8 TB raw storage per node		
Network Adapter	2-port 100 Gbps Intel Ethernet Network Adapter E810- CQDA2 - 100 Gbps		
Estimated Hardware Cost (4 nodes)	\$60,004		
Estimated Solution Cost	\$496,564		
Plus Conf	Plus Configuration		
CPU	Intel Xeon Gold 6348 28 Cores/56 Threads 2.6GHz		
Memory	128 GB 3200MHz DDR4 DRAM 1,024 GB Intel Pmem 200 Series Persistent Memory		
Storage	3.84TB Intel SSD DC P5510 Series 8 drives, 30.72 TB raw storage per node		
Network Adapter	2-port 100 Gbps Intel Ethernet Network Adapter E810- CQDA2 - 100 Gbps		
Estimated Hardware Cost (4 nodes)	\$100,988		
Estimated Solution Cost	\$537,548		



Table 2. DiskSpd Benchmark Parameters

Parameter	Value
# of Virtual Machines	4
# vCPU per VM	4
Memory per VM	8 GB
Allocated Storage per VM	40 GB
vCPU Utilization per VM	90%
Block Size	4 KB
Threads per VM	4
Duration	300 seconds

Table 3. HammerDB Benchmark Parameters

Parameter	Value
# of nodes in cluster	4
# of Virtual Machines	1-8
# vCPU per VM	24
Memory per VM	128 GB
Allocated storage per VM	2 GB
HammerDB Version	4.0
HammerDB Warehouses	800
Database size	80GB
Virtual Users	150

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